DOCUMENT RESUME

ED 299 923 HE 021 917

AUTHOR Novak, Joseph D.; Ridley, Dennis R.
TITLE Assessing Student Learning in Light of How Students Learn.
INSTITUTION American Association for Higher Education, Washington, D.C.
PUB DATE 88
NOTE 29p.; Paper collected as part of the American Association for Higher Education Forum.
AVAILABLE FROM AAHE Assessment Forum, American Association for Higher Education, One Dupont Circle, Suite 600, Washington, DC 20036.
PUB TYPE Viewpoints (120) -- Guides - Non-Classroom Use (055)

EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS *Academic Achievement; *Cognitive Style; *Educational Assessment; Higher Education; Instructional Effectiveness; Outcomes of Education; Student Development; Teacher Role
IDENTIFIERS *AAHE Assessment Forum; *College Outcomes Assessment

ABSTRACT

The questions of purposes and methods as related to assessment of student learning are considered. It is difficult to find assessment invoked without a parallel call for improvement, particularly improved teaching and learning. Also, much attention has focused on problematic dimensions of measuring what students learn, but the fundamental set of questions about the match between purposes and methods tends to get bypassed. Six sections focus on the following: a rationale for the approach taken here and the problem that prompts it; principles of assessment grounded in a view of how students learn; a theory of learning, set forth not as the final word but as a possible framework for "theory-driven" assessment; three assessment techniques that follow from that theory (the structured interview, concept mapping, and Gowin's Epistemological Vee); an evaluation of the three techniques in light of experience of their use and other considerations; and a revisitation of the thesis (where it has gone, and where it will go next). Positive steps for the assessment movement include (1) encouraging faculty to talk to each other about meaningful learning and (2) developing a greater and more diverse array of methods. Contains 27 references. (SM)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED299923

Assessing Student Learning In Light Of How Students Learn

by Joseph D. Novak
and
Dennis R. Ridley

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

AAHE

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

☑ This document has been reproduced as received from the person or organization originating it.

☐ Minor changes have been made to improve reproduction quality.

• Points of view or opinions stated in this document do not necessarily represent official OERI position or policy

HE 021 917

THE AAHE ASSESSMENT FORUM

AMERICAN ASSOCIATION FOR HIGHER EDUCATION

One Dupont Circle
Suite 600
Washington, D.C. 20036
202/293-6440

AMERICAN ASSOCIATION
FOR HIGHER EDUCATION

Board of Directors

Chair
Joseph F. Kauffman
University of Wisconsin
Madison

Chair-Elect
Adele S. Simmons
Hampshire College

Vice Chair
Reatha Clark King
Metropolitan State University

Past Chair
Harriet W. Sheridan
Brown University

Carlos H. Arce
NuStats, Inc.

Estela M. Bensimon
Teachers College
Columbia University

Anne L. Bryant
American Association of
University Women

Donald L. Fruehling
McGraw-Hill, Inc.

Ellen V. Futter
Barnard College

Jerry G. Gaff
Hamline University

Zelda F. Gamson
University of Michigan

Stephen R. Graubard
Daedalus

Joseph Katz
State University of New York
at Stony Brook

Arthur E. Levine
Bradford College

Frank Newman
Education Commission
of the States

Alan Pifer
Carnegie Corporation
of New York

W. Ann Reynolds
The California State
University

Piedad F. Robertson
Miami-Dade Community
College

D. Wayne Silby
Groupware Systems

P. Michael Timpane
Teachers College
Columbia University

President
Russell Edgerton

The AAHE ASSESSMENT FORUM is a three-year project supported by the Fund for the Improvement of Postsecondary Education. It entails three distinct but overlapping activities:

--an annual conference
(the first scheduled for June 14-17, 1987, in Denver)

--commissioned papers
(focused on implementation and other timely assessment concerns; available through the Forum for a small fee)

--information services
(including consultation, referrals, a national directory, and more)

This paper is part of an on-going assessment collection maintained by the Forum. We are pleased to make it more widely available through the ERIC system.

For further information about ASSESSMENT FORUM activities, contact Patricia Hutchings, Director, AAHE ASSESSMENT FORUM, One Dupont Circle, Suite 600, Washington, DC 20036

ASSESSING STUDENT LEARNING IN LIGHT OF HOW STUDENTS LEARN

Dennis R. Ridley
Christopher Newport College

and

Joseph D. Novak
Cornell University

Prepared for:

The AAHE Assessment Forum
American Association for
Higher Education

When Francis Bacon wrote almost four hundred years ago that all innovations "at first are ill-shapen," he could have been describing the initial, tentative efforts of those of us in higher education to assess our impact on student learning. Given the dearth of appropriate instruments and technologies, the pressures of external mandates from states and accreditors, and the internal concerns of faculty and others about the misuse of assessment, it's no wonder that what has been done in the name of assessment thus far has occasionally been mistaken or "ill-shapen." The movement is still in an early stage, and efforts are bound to be unsophisticated.

Experience is growing, however. Whereas a few years ago literature on assessment was thin and hard to find, much is now available. Opportunities such as workshops and conferences for campuses to share ideas now abound. The time is right for moving practice to a more sophisticated stage, taking on the next hard questions. This paper focuses on two such questions.

First, there's a question about purposes. It's hard to find assessment invoked without a parallel call for improvement, particularly improved teaching and learning. The assessment guidelines issued by the State Council of Higher Education of Virginia, for example, state that "the purpose of assessment is not to compare institutions but to improve student learning and performance." But it's noteworthy that the student experience of assessment is seldom cited or discussed either in state guidelines or campus plans. The question, then, is how we can turn the rhetoric of improvement into reality. How can assessment be not only *of* students but much more directly and immediately *for* them?

The second question--or set of questions--focuses on methods as related to purposes. A good deal of attention has been focused on problematic dimensions of measuring what students learn--particularly in terms of "value added" by the educational experience. Because it is increasingly linked with high-stakes decision making, assessment brings to the surface a number of fundamental difficulties in doing so. Methodological difficulties (the validity of gain scores for instance) are receiving considerable attention, and a number of assessment leaders are calling for "a new psychometric theory" more suited to the purposes of assessment. In a sense, however, these concerns bypass a more fundamental set of questions about the match between purposes and methods: What kinds of learning do we care enough about to assess? What is the nature of that learning and what do we know about how students acquire it? What are the implications of these questions for our choice of assessment methods?

These two broad questions represent challenges to the next stage in the development of assessment programs. Our thesis in this paper is that they can be met only when assessment is grounded in understandings (theory, if you will) of how students learn.

Six sections follow:

1. a rationale for the approach taken here and the problem that prompts it

2. principles of assessment grounded in a view of how students learn

3. a theory of learning--set forth not as the final word but as a possible framework for "theory-driven" assessment

4. three assessment techniques that follow from that theory

5. an evaluation of the three techniques in light of experience of their use and other considerations

6. a revisitation of the thesis: where it has taken us, and where we need to go next.

PART ONE: THE PROBLEM AND THE APPROACH

This paper grows out of the conviction that traditional understandings of educational processes and their measurement (educational and psychometric theories) have not served the assessment movement well in a foundational sense. They have perpetuated narrow notions of educational processes and of what the production and transmission of knowledge are all about. Alexander Astin (1987) puts the case sharply: "Psychometricians have mesmerized us with the normal curve." Assessment methods that yield norm-referenced scores, Astin argues, lose the most important information: what a person knows or has learned.1

Astin's objection is to a mismatch between a measurement technique--a certain kind of standardized test--and what it is we want to know. The widespread use of standardized

tests in assessment suggests that we are bypassing what is arguably the most crucial question: what kind of learning do we care enough about to assess? The premise of this paper is that assessment must begin with a view of learning and that learning--or educational change--is fundamentally about change in the meaning of experience.

The thrust of this definition is best illuminated by contrast with the view that appears to undergird (probably by default) much assessment practice today, and which has been variously called positivism, empiricism, or objectivism.

According to this view, the goal of knowing is to discover "true" knowledge, and the goal of education is to impart it to others. These achievements are objective matters, to be determined, in turn, by objective tests. The scholar discovers truth; the learner demonstrates she knows truth by correct responses on discrete items. The model is a behaviorist one: a view of learning in which a stimulus (S) from the environment produces a response (R) from the organism, resulting, with repetition, in an S-R bond. All references to experience, meaning, or (especially) changes in the meaning of experience, are anathema in this positivist epistemology and view of learning.

The problem, vis a vis assessment, lies in the ways such objectivist/behaviorist models have shaped measurement theory and practice. Stephen J. Gould, Harvard biologist and geologist, has been a long-time critic of the psychometric applications to education of this objectivist orientation. In The Mismeasure of Man (1981), Gould sets forth several dangers of these methods.

Although "objective" in a statistical sense, such methods give a narrow, one-dimensional view of student performance and learning. Gould warns of "reification," the positing of an objective "something" --e.g. spatial ability, or whatever--in which persons are said to vary. Even worse is the danger that some reified, abstract quality, represented by a single score in many cases, will be used to classify students, and in the worst case, exclude them from opportunities to learn.

A second pitfall of building assessment on objectivist measurement techniques is one of validity. There is growing evidence that objectivist theories do not, in fact, describe and predict how human beings actually learn. They fail to give an account of what changes when learning occurs. Part Three of this paper will look in depth at one alternative view of learning--that of David Ausubel--and use it to explore assessment implications. Suffice it to say here that recent research on learning clusters around a "constructivist" model, one that, in contrast to the

positivist's linear, additive view of learning, suggests that learners construct knowlege by applying what they already know in order to make sense of new phenomena.

The point here is not to suggest that one view of learning precludes another, that one must be completely discarded as the new and improved model becomes available. It is, rather, to suggest that assessment methods are by necessity grounded in such views, and as we select and design assessment methods to use on our own campuses with our own students, it's important to keep an eye on matching methods to what we believe about how students learn.

PART TWO: STUDENT-CENTERED ASSESSMENT

Before moving into theories of learning and how they can provide a foundation for assessment, it may be helpful to set forth, briefly, some guidelines for assessment that is not only <u>of</u> students but <u>for</u> them.

1. Adopt assessment methods that permit accurate diagnosis of the learner's strengths and weaknesses.

Diagnosis is more easily said than done; it requires more subtle instruments than much of what is now available. A key to successful diagnosis lies in eliciting not only what the student doesn't know but what she does.

2. Use assessment methods that help students take responsibility for their own learning.

An element in outcomes assessment that is often neglected is student effort--the fact that learning is an active process for which students share responsibility. Assessment for students means choosing methods that involve students. Conversely, it means avoiding methods that treat learners as passive recipients of so-called objective truth.

3. Monitor student progress by a broad range of methods.

No important decision about a student (or for that matter a program or institution) should be made on the basis of a single score or indicator. A valid picture of student performance is a composite one, the result of samples taken over time, in a range of situations, by different methods.

4. Use methods that allow flexible, timely feedback connected to the events of students' learning.

It has become a truism of the assessment movement that feedback is essential. A next step is to develop more systematic principles of feedback: what kinds of information, delivered at what points and in what forms, are most conducive to learning?

5. Adopt a holistic approach: consider feelings, attitudes, and values, not merely cognitive indicators.

Assessment calls for a wider view of student learning and development--a look at outcomes that transcend individual courses. Affective as well as cognitive development should be considered.

6. Invent or adopt methods that are grounded in and conducive to the character of learning we care about.

If assessment is to lead to improved learning, its methods must be congruent with the best thinking available on teaching and learning.

The next section of this paper takes this last principle seriously by delineating one thoughtful theoretical foundation for assessment.

PART THREE: TOWARD A THEORY OF MEANINGFUL LEARNING

As indicated earlier, recent work in learning theory clusters around a notion of knowledge as an active "construction." Familiar examples include Kuhn's (1962) work in "paradigm shifts," and work coming out of various disciplines on "collaborative learning." One thinks, as well, of the 1985 NIE report, Involvement in Learning, which reflects a similar view.2

Behind such developments is a concept of learning which holds that information becomes meaningful and memorable only through an active process of assimilation (Bartlett, 1932). The human learner (from novice to sophisticated scholar) constructs knowledge by assimilating new inputs into already existing, organized networks of knowledge. This view stands opposed to behaviorist or stimulus-response models of learning that claim significant learning occurs in a more additive or associational way.

From this contrast arises the key distinction between meaningful and rote learning. It is the distinction that expert teachers make when they recognize whether students are merely repeating bits of information or are beginning to "understand." The difference between relatively more or less sophisticated persons does not lie simply in how much more some persons know, expressed as sheer quantity of facts, but rather in the organization of concepts in their minds, and how well they grasp the underlying structures of knowledge which characterize (for instance) a given academic discipline.

Assimilation Theory

Growing out of over thirty years of applied educational research (Ausubel, Novak and Hanesian, 1978, 1986), David Ausubel's assimilation theory provides a useful case in point of a larger universe of theories that critique rote-learning approaches (e.g.. Anderson, Spiro and Montague, 1977; Bransford, 1979; Kintsch, 1974; and many others). We turn to Ausubel's theory as an example of such views and as a vehicle for illustrating how a theory of learning can give rise to assessment techniques--techniques both rooted in a theory of learning and designed to promote such learning in students (assessment for students).

A simple statement of Ausubel's fundamental idea is this: "If I had to reduce all of educational psychology to just one principle, I would say this: 'The most important single factor influencing learning is what the learner already knows. Ascertain this and teach him accordingly'" (Ausubel, 1968). In other words, learners "create new knowledge out of what's already in their heads" (McKeachie, 1987).

This "constructivist" view is essentially an effort to integrate the psychology of human learning and the epistemology of knowledge construction.3 The key to this integration is that concepts and interrelated networks of concepts, or propositions, comprise the central elements in both knowledge production and human learning. Concepts are, if you will, the coin of meaning; they are what we think with and understand through. As human knowledge production can be described in terms of "evolving populations of concepts" (Toulmin, 1972), so human learning can be charted in terms of changes in conceptual frameworks. Moreover, to claim that meaningful learning is conceptual is to suggest that new learning is facilitated by adequate and relevant concepts.

Moreover, if concepts are what we think and understand with, assimilation theory also suggests that learners must actively pursue their own conceptual growth. Whereas rote learning is characterized by arbitrary connections involving

no interaction between what is learned and the knowledge the learner already has, the learning postulated by people like Ausubel (and the learning most educators care about) involves an active quest to relate new knowledge to the relevant concepts and principles the student has previously at hand.

For these reasons, gaining competence in meaningful learning is often described as "empowering" the learner, or "learning how to learn."

The Rote/Meaningful Learning Continuum

What are the identifiable changes associated with meaningful learning? As the learner moves toward the "meaningful" end of the rote/meaningful learning continuum in a given discipline, his or her conceptual structures begin to resemble those of an expert in the field. Their organization becomes more complex and takes on a form which can be represented hierarchically, with the most powerful, overarching concepts at the top and subsidiary ones below.

Without getting bogged down in technical language, it's useful to have in view four key processes that characterize meaningful learning. As the following typology indicates, meaningful (vs. rote) learning is facilitated by instruction that encourages subsumption, integrative reconciliation, superordinate learning, and progressive differentiation.

Four key processes in Ausubel's theory of facilitating meaningful learning:

Meaningful Learning - New knowledge is concisely linked to existing concepts and propositions in cognitive structure and incorporated into these concepts. Learning moves higher on the rote/meaningful continuum when the following processes are facilitated.

Subsumption: incorporation of new knowledge into a specifically existing concept or proposition

e.g. students identify the "moon illusion," that the apparently larger size of the moon when it appears near the horizon is a form of perceptual illusion.

Integrative Reconciliation: new learning that results in explicit delineation of similarities and differences between related ideas

e.g. students analyze hallucinatory phenomena, by distinguishing hallucinations from illusions, false perceptions, etc.; comparing hallucinations with organic vs. functional roots; comparing them with other abnormal phenomena.

Superordinate Learning: new concepts or propositions acquired that connect the meanings of two or more related, less inclusive ideas

e.g. students learn the concept of "marsupial" to embrace such animals as kangeroos, opossums, and wombats.

Progressive Differentiation: elaboration and clarification of meanings or concepts or propositions occurring over time as new subsumption, integrative reconciliation, and/or superordinate learning occurs

e.g. students expand their understanding of the concept of measurement as they learn about validity, reliability, levels of measurement, etc.

As indicated by the examples above, Ausubel's view of learning (like other current views) rejects the notion that "meaningful" learning occurs along a simple learning curve, in which uniform bits of learning accumulate. Rather, it involves the extension of old concepts or the creation of new concepts out of old ones (subsumption); it involves acquisition of a wholly new higher-order concept (superordinate learning); or, in the most creative leaps, major restructuring of the way concepts had been linked may occur. In the latter cases, one's very perceptions of the world can be changed: planetary motion and the behavior of falling terrestrial objects are perceived as similar, for example (integrative reoncilation). Gowin (1981) talks about such learning as "coming into possession of one's world."

What are the implications of this view of learning for assessment?

First, learners come to every learning situation--including assessment--with some relevant concepts already in place; they bring, that is, some power to learn. Appropriate strategies for both teaching and assessment, then, are those which identify the relevant concepts a learner has and elicit their use in order to produce new learning. When this is done successfully, it is possible to

observe (and measure) movement from predominantly rote learning to the kind of learning characterized by the four processes above. It is our contention that assessment should focus on changes of this nature rather than (as is often the case) discrete, narrowly defined changes in behavior such as the number of items passed on a multiple-choice test.

Second, the description and measurement of these changes require tools that begin to meet the challenges set forth at the beginning of this paper: to devise assessments that address the kind of learning we care about, and to ensure that assessment is not only of students but for them. In short, meaningful assessment begins with a view of meaningful learning. In the next section we look at examples of such assessment.

PART FOUR: THREE ASSESSMENT TECHNIQUES

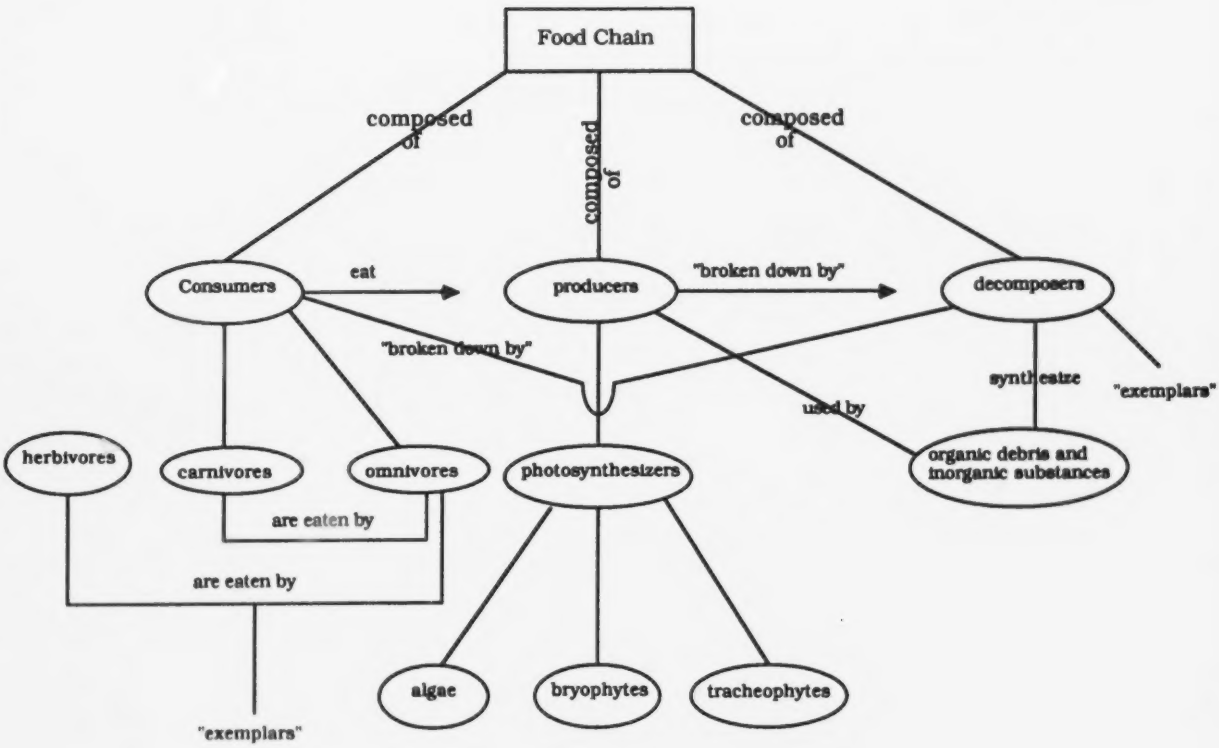
There are, of course, numerous assessment techniques which might follow from the theoretical framework suggested in Part Three. What follows are three examples: the structured interview, concept mapping, and Gowin's Vee.4 It should be noted, at the outset, that the primary impetus behind all three was pedagogical; they were designed for teaching rather than for assessment. In part for that reason, they represent powerful assessment possibilities.

The Structured Interview

As campus assessment plans expand and develop, the interview is a frequently considered option, an attractive one for those seeking more full-bodied, qualitative information about student learning and development. Interviews can be particularly productive when they are shaped around conceptual maps which depict a field of knowledge in terms of key concepts and their interrelationships.

An example of a discipline-specific conceptual map used to plan interviews assessing students' understanding of the food chain is shown below:

Concept Map
of the Food Chain



(Novak and Gowin, 1984, p. 122)

Working from such a map, the assessor prepares a list of questions and probes, such as "Is every plant a producer?" Auxiliary materials or props (e.g. photos of environmental scenes) are selected to guide the interview process. Questions are constructed so that students are required to use their concepts about the food chain to respond to questions and situations posed by the interviewer. From those responses, it is possible to construct a cognitive map that represents key concepts and relationships as understood by the student. The objective of the interview is to draw out the student's conceptual map and to compare it to that of an expert in the field.

14

The structured interview entails several benefits relevant to the character and facilitation of meaningful learning:

- It reveals what the student already knows about the subject.

- It uncovers discrepancies between the "ideal" conceptual map (that shared by experts in the field) and the student's. Discrepancies often represent faulty propositions (such as "bacteria is decay") held by the student. This is important diagnostic feedback for both student and teacher.

- When repeated following instruction, the structured interview can reveal changes in understanding through the student's correction of omissions and false propositions.

Further guidance in conducting the structured interview can be found in Learning How to Learn, by Joseph Novak and D. Bob Gowin (Cornell University, 1984).

Concept Mapping

Structured interviews provide meaningful information about learning, but they are labor-intensive. Some would argue that the method is too complicated and time-consuming for teachers to use in routine class evaluation. Concept mapping provides an alternative.

In contrast to the structured interview--where the assessor must construct the student's cognitive map by inference from his or her answers--concept mapping calls on students to construct their own maps, indicating concepts as labelled circles or boxes and showing the relationships among concepts by connecting lines with appropriate labels. Concept mapping is a technique which allows a student to demonstrate what he or she knows in a dramatic, visual form.

Concept maps have clear benefits. They help learners identify the key concepts to be learned, and show links between what is to be learned and what he or she already knows. They provide a particularly revealing way to look at changes in learning. By comparing successive versions of the student's map of, say, the food chain, the assessor can determine how the student's learning has changed.

The contrast with the typical multiple-choice standardized test is noteworthy here: The test yields a score (or change in a score)--a proxy for the actual learning; concept mapping allows one to observe the learning itself.

Scoring systems have been designed for concept maps. The basis for scoring systems is the quantification of meaningful learning relative to some discipline area. Credit is given not only for the number of valid propositions or concept linkages, but even more importantly, for the number of valid hierarchical levels shown. Still more important is the number of cross-links or lateral connections. These can indicate instances of what Ausubel calls "integrative reconciliation," a mark of meaningful (vs. rote) learning and a mode of thinking related to creativity (Novak, 1977).

The following figures illustrate, first, a general scoring model for concept maps and, second, an application of this model to an understanding of musical composition.

Scoring Model

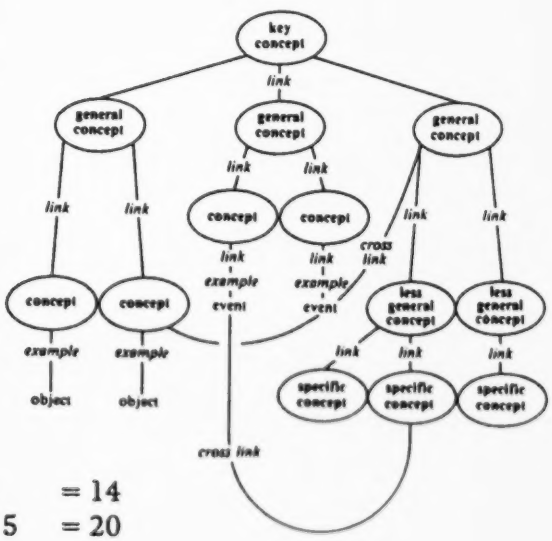
Hierarchy

Level 1

Level 2

Level 3

Level 4



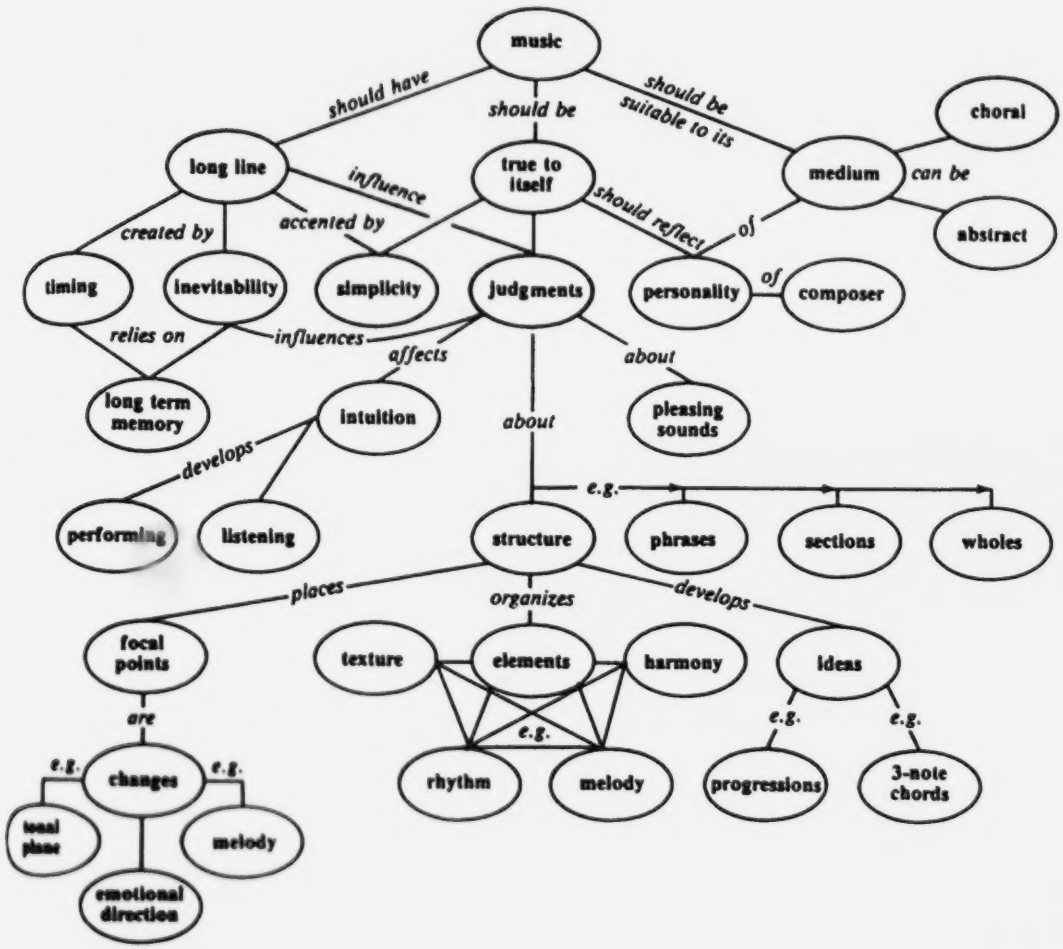
Scoring for this model:

Relationships (if valid)	= 14
Hierarchy (if valid) 4 x 5	= 20
Cross links (if valid and significant) 10 x 2	= 20
Examples (if valid) 4 x 1	= 4
	58 points total

(Novak and Gowin, 1984, p. 37)

16

Scoring Model Applied to Concept Map
for an Experienced Musical Composer



Scoring for this example:

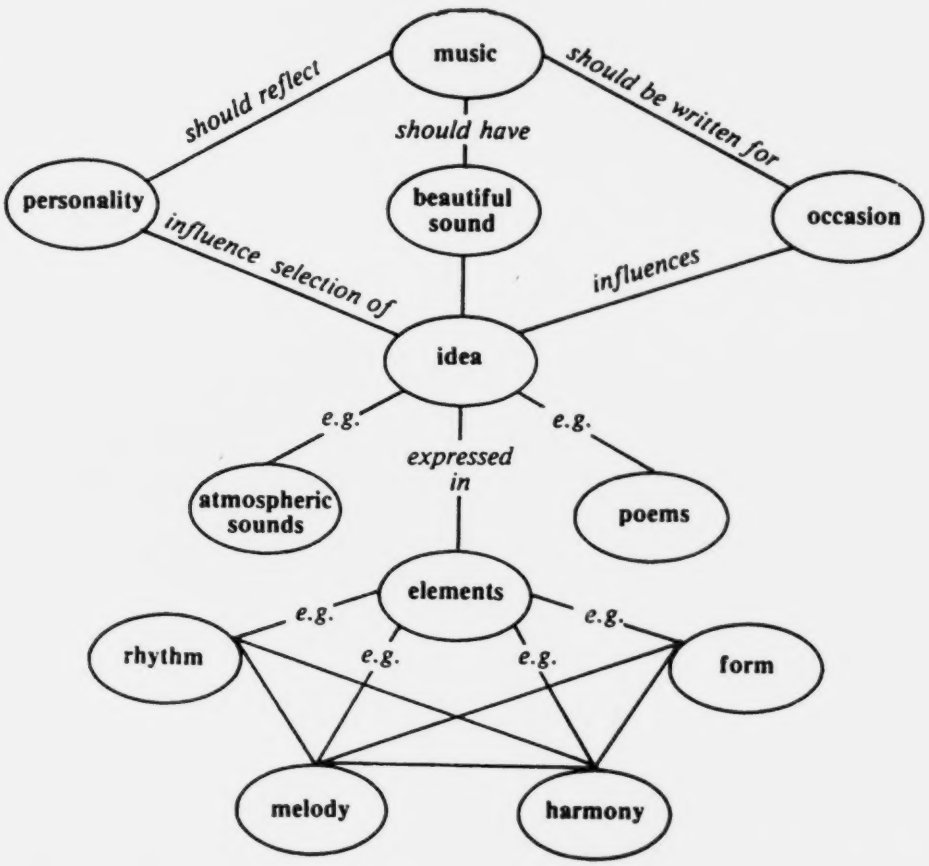
Relationships:	29
Hierarchy: 6x4	24
Cross-links: 10x1	10
Examples:	6
	69 Total

(Novak and Gowin, 1984, p. 147)

17

The next example of scoring a concept map reveals a dramatic contrast between the experienced composer and the novice. Note the low score earned by this map in comparison with the one above.

Concept Map for a Novice Composer



Scoring for this example:

Relationships:	7
Hierarchy: 4x4	16
Cross-links	0
Examples	6
	29 Total

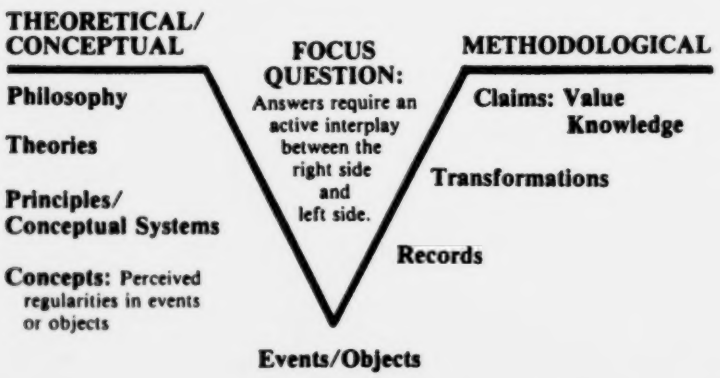
(Novak and Gowin, 1984, p. 148)

As with structured interviews, a major argument for using concept maps is that they possess construct validity: a direct correspondence between the elicited performance and the organization of cognitive structure as predicted by theories of learning. Construct validity calls attention to both the validity of the underlying view of learning and the match between that view and the method of assessment.

Gowin's Epistemological Vee

Gowin's Vee was designed to help students understand the structure of knowledge and the ways people produce knowledge. The Vee is a diagram which helps to display the epistemological elements that are involved in any new knowledge ("epistemological elements" being those units that together form the structure of a segment of knowledge). They can be divided into the "thinking" (conceptual) and "doing" (methodological) elements, as shown below. The left side contains references to theory, principles, concepts, etc., and the right side shows the record of events, the transformations of data, and claims of value or knowledge that can result from an inquiry. The point of the Vee is downward toward the events or objects that the student is being called upon to understand.

Gowin's Epistemological Vee



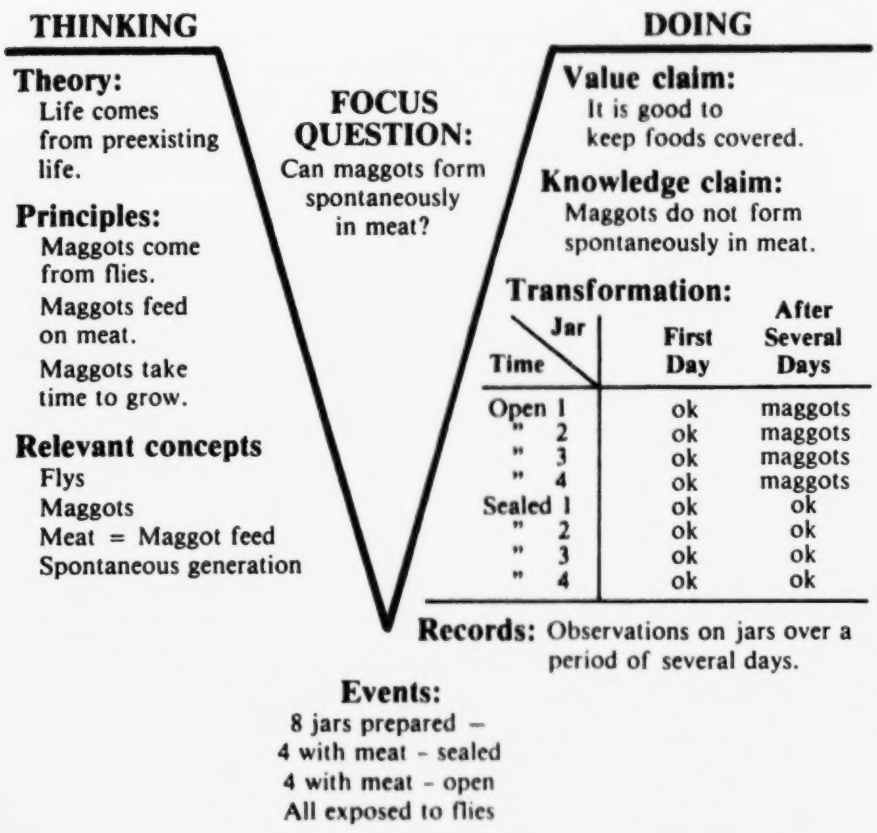
(Novak and Gowin, 1984, p. 3)

Science laboratory instruction is a particularly appropriate setting for illustrating the use of the Vee (although many other applications exist) because such instruction is explicitly directed at guiding students through the re-creation of knowledge. The Vee diagram was, in fact, designed to counteract discouraging results of science lab instruction, where research shows that the large majority of students have little or no understanding of how

the results of their work could be explained (Robertson-Taylor, 1985). Many students simply follow procedures without understanding the reasons for them; they are, if you will, procedurally-bound, going through the motions without reflecting on their meaning.

The Vee is a heuristic device to help students understand the link between the theories, principles, and concepts of the discipline and what happens in the laboratory. The Vee below is based on the description of an experiment in a biology textbook.

An Example of a Vee Diagram
from Biology



(Novak and Gowin, 1984, p. 115)

In the experiment on which this Vee is based, the focus question, "Can maggots form spontaneously in meat?" is conclusively answered. However, the selection of events to observe, and the records and transformations made--i.e., the methodology--can be understood clearly only when the relevant conceptual elements are correctly identified.

Conversely, the conceptual elements, principles, and theory are better understood in the light of the experiment than in the abstract. In the move from one side of the Vee down to the event, and back up the other side, the construction of this particular segment of knowledge is demystified. The heuristic helps the learner not to become caught up in procedures without understanding them. Further examples of Vee maps, from a variety of disciplines, can be found in Learning How to Learn, by Novak and Gowin (1984).

Gowin (1987) has proposed the Vee as an assessment tool as well as a pedagogical device. The various epistemological elements on the Vee can be used to assess how students make sense of a discipline. Do they function as an expert in the field does, by demonstrating the active interplay between the two sides of the Vee? Do they understand the theoretical and conceptual considerations that lead to asking particular questions and focusing on particular events and objects? Or are they more or less preoccupied with collecting data--to the exclusion of seeking meaning in what they are doing?

Scoring schemes for the Vee are in a developmental phase. Essentially, scoring involves assigning points to different epistemic elements of the Vee when they are correctly identified. For example, a student who is constructing a Vee for the experiment discussed above should identify the theoretical proposition underlying the experiment: "Life comes from pre-existing life." She should also identify key principles and concepts.

A simple scoring guide consists of scaled criteria for each epistemic element (Novak and Gowin, 1984, p. 77). For example, a score for the student's understanding of theory, principles, and concepts (from the left side of the Vee) can be derived from the following scale:

0 - No conceptual side is identified
1 - A few concepts are identified, but without principles and theory
2 - Concepts and at least one type of principle (conceptual or methodological) or concepts and relevant theory are identified
3 - Concepts and two types of principles or concepts, one type of principle, and a relevant theory are identified.
4 - Concepts, two types of principles, and a relevant theory are identified.

Using this guide, the Vee above (depicting a biology experiment) would receive the full four points. Other elements of the Vee can be scored similarly (Novak and Gowin, 1984).

In addition to having construct validity, assessment based on Vee-mapping may be said to have "epistemological validity," i.e., demonstrating a sound view of human knowledge and how it is generated. The Vee is based on a "constructivist" view of knowledge, as contrasted to the positivist epistemology discussed earlier. It is concerned with how the student creates new knowledge, with knowledge as human construction, as opposed to the static or "objective" kinds of learning that are often assessed.

PART FIVE: PRACTICAL CONSIDERATIONS AND EVALUATION OF TECHNIQUES

Novak (1988) reports widespread use of concept maps and Vee diagrams beginning to be reported, but most of the reports so far stem from dissertation work done at Cornell University. Novak's summary of teaching and assessment applications at the higher-education level shows that:

- most students demonstrate success in constructing concept maps;
- when rote learning suffices for success and when tests do not require meaningful learning, concept mapping is less likely to be adopted (Moreira, 1977);
- reluctant users of concept maps become enthusiastic when they find difficult topics become conceptually clear and misconceptions disappear;
- both concept mapping and Vee diagrams can make science laboratory experience more meaningful and satisfying for students (Robertson-Taylor, 1985);
- willingness to adopt the techniques requires faculty/institutional commitment to meaningful learning and a sacrificing of short-term higher performance on tests that stress rote learning.

The major obstacle to adoption is "the predominantly rote-mode teaching practices encouraged (or required) in so much of school-university learning (which puts) 'braces on the brains' of many students" (Novak, 1988, p. 14). In addition, Fountain (1988) reports a successful and enthusiastic response to concept mapping in chemistry classes at Northeast Missouri State University.

As indicated earlier, a clear strength of techniques like those discussed in Part Four is their construct and epistemological validity. In addition, they meet the pragmatic criterion of predictive validity. According to Novak and Gowin (1984), these techniques increase predictive validity far beyond that achieved through standardized tests, which seldom account for more than 20% of the variance in subsequent measures of achievement. The failure of standardized achievement tests to predict subsequent achievement can be explained in terms of the relatively low-level conceptualizations measured by these tests (Novak, 1975). The contrasting success of the three techniques presented here is due to their grounding in the student's ability to use higher-order, broadly generalizable concepts that transfer to a wide variety of settings.

Liabilities of these techniques should also be noted. They are, to one degree or another, labor-intensive and complex; some expertise is required for design, administration, scoring, and interpretation. A second objection is the non-standardization of responses, and the related limitation that these techniques do not lend themselves to aggregate data, generalized across students and courses.

These are legitimate concerns. To address them, one must return to questions of purpose. If, for instance, the purpose of assessment is to provide state agencies with simple, bottom-line data for decision making, complex, qualitative methods like the ones discussed in this paper will not be appropriate.

If, however, assessment is directed at improving student learning, such methods warrant consideration despite the difficulties they may present. Creative ways may be found to mitigate the conflict between the need for program-wide aggregation of assessment results, on the one hand, and assessment of individual student learning, on the other. Results from even a small sample of students might provide rich material for faculty reflection about teaching and curriculum.

Moreover, we believe it is better to be in the position where the summarizing of valid data is difficult than to be in the position where valid inferences from standardized data, down to the events of meaningful learning in the classroom, are hazardous at best. If the focus of assessment is on the learner's experience, on helping learners come into possession of their world, then techniques that are grounded in those critical educative events are what we need more of in assessment.

Bouton (1986) is an eloquent spokesman for this position: "It is much easier to devise outcome measurements than to understand the complex learning process in the classroom. But unless assessment is based on the experience of what happens in the classroom, it is limited to selecting certain outcomes and validating those educational methods which produce the outcomes as defined by the assessment instrument." Assessment grounded in an understanding of how students learn offers a way out of the circularity described by Bouton.

Cognitive psychologists have made considerable strides in the understanding of complex learning. Although devising and using techniques that are based on this understanding is difficult, it is a needed corrective to procedurally driven, narrow forms of assessment.

PART SIX: SUMMARY AND CONCLUSIONS

This paper is an elaboration of the thesis that effective assessment must be based on clear ideas about how students learn and what kinds of learning we care about. It discusses three techniques which both measure and enhance what Ausubel calls "meaningful" learning.

Finally, however, our concern is less with specific theories of learning and particular techniques for assessment than with a general need for more, and more powerful, assessment designed to enhance student growth. There are encouraging signs afoot that the mood of practitioners is shifting away from a narrow view of student learning (which we connect to a positivist view of knowledge). One such sign is a recently noted decline in the use of standardized tests for assessment purposes (Ewell, 1987).

Moreover, assessment grounded in understandings of how students learn is assessment that will benefit students. It is assessment that is driven by faculty views of meaningful learning. A modest first step toward the kind of assessment called for here, then, is to encourage faculty to talk to each other about meaningful learning, and how it occurs. Our experience is that, for many faculty, this is an engaging topic, one they have indeed thought about, one that provides a frame of reference for collaborative work across disciplines.

A positive next step for the assessment movement will be the development of a greater and more diverse array of methods. The three techniques discussed in this paper are a starting point--examples around which further efforts at assessment that is truly for students can be built.

FOOTNOTES

1. Astin elaborates on this issue in his presentation from the Third National Conference on Assessment in Higher Education (June 8-11, 1988), "Assessment and Human Values: Confessions of a Reformed Number Cruncher." His remarks focus particularly on the student's experience of multiple-choice standardized tests and what they signal about our educational values and expections. Astin's remarks (together with those by Robert H. McCabe and Linda Darling-Hammond, the other two plenary speakers at the conference) are available from the AAHE Assessment Forum; information on ordering appears at the back of this publication.

2. In examining meaningful student learning, we deliberately focus for the most part on one key element in education--the nature of learning or educational change. In addition to learning, at least three other concepts must be considered in any complete theory of education: teaching, the curriculum, and the context in which teaching and learning occur (Novak, 1977; Schwab, 1973).

3. An extended treatment of this integration between the psychology of human learning and the epistemology of knowledge construction may be found in Novak (1987).

4. It should be noted that the three techniques to be described were not, strictly speaking, derived from Ausubel's theory. However, they have been used extensively in conjunction with the theory, developed by those who are familiar with and use the theory, and are compatible with it.

REFERENCES

Anderson, R.C., Spiro, R.J., & Montague, W.E. (1977). Schooling and the Acquisition of Knowledge. Hillsdale, N.J.: Lawrence Erlbaum Associates.

Astin, A.W. (1987). "Campus Values: From Competition to Cooperation." Presentation at the National Conference of the American Association for Higher Education, Chicago, March 3, 1987 (audio tape).

Astin, A.W. (1988). "Assessment and Human Values: Confessions of a Reformed Number Cruncher," in Three Presentations, 1988. Washington D.C.: The AAHE Assessment Forum.

Ausubel, D.P. (1968). Educational Psychology: A Cognitive View. New York: Holt, Rinehart and Winston.

Ausubel, D.P., Novak, J.D. & Hanesian, H. (1978). Educational Psychology: A Cognitive View (2nd Ed.). New York: Holt, Rinehart and Winston. Reprinted 1986, New York: Warbel and Peck.

Bartlett, F.C. (1932). Remembering. Cambridge, England: Cambridge University Press.

Bouton, C. (1986). "Assessment and the Reification of Learning." In Proceedings from the Conference on Legislative Action and Assessment: Reason and Reality, Arlington, VA., July 7-9, 1986.

Bransford, J.D. (1979). Human Cognition. Belmont, CA: Wadsworth.

Ewell, P.T. (1987). "Assessment: The State of the Art." Presentation at the National Conference of the American Association for Higher Education, Chicago, March 2, 1987 (audio tape).

Feldsine, J.E., Jr. (1987). The Construction of Concept Maps Facilitates the Learning of General College Chemistry: A Case Study. Ithaca, N.Y.: Unpublished Ph.D. dissertation, Department of Education, Cornell University.

Fountain, K.E. (1988). Personal communication.

Gould, S.J. (1981). The Mismeasure of Man. New York: Norton.

Gowin, D.B. (1981). Educating. Ithaca, N.Y.: Cornell University Press.

Kintsch, W. (1974). The Representation of Meaning in Memory. Hillsdale, N.J.: Lawrence Erlbaum Associates.

Kuhn, T.S. (1962). The Structure of Scientific Revolutions. Chicago: University of Chicago Press.

McKeachie, W.J. (1987). "Classroom, Curriculum, Climate: Which Has the Greatest Potential for Improving Teaching and Learning?" Panel presentation at the National Conference of the American Association for Higher Education, Chicago, March 3, 1987 (audio tape).

Moreira, M. (1977). An Ausubelian Approach to Physics Instruction: An Experiment in an Introductory College Course in Electromagnetism. Ithaca, N.Y.: Unpublished Ph.D. dissertation, Department of Education, Cornell University.

NIE Study Group on the Conditions of Excellence in American Higher Education. Involvement in Learning: Realizing the Potential of American Higher Education. Washington, D.C.: U.S. Government Printing Office, 1984.

Novak, J.D. (1975). "The Use of Ausubel's Cognitive Psychology to Model Creative Ability as Distinguished from Abilities Measured by Standardized Achievement Tests." Paper presented at the 48th annual meetings of the National Association for Research in Science Teaching, March 19, 1975.

Novak, J.D. (1977). A Theory of Education. Ithaca, N.Y.: Cornell University Press.

Novak, J.D. (1987). "Human Constructivism: Toward a Unity of Psychological and Epistemological Meaning Making." Paper presented at the Second International Seminar on Misconceptions and Educational Strategies in Science and Mathematics Education. Ithaca, N.Y.: July 27, 1987.

Novak, J.D. (1988). "Concept Maps and Vee Diagrams: Two Meta Cognitive Tools for Science and Mathematics Education." Unpublished manuscript.

Novak, J.D. & Gowin, D.B. (1984). Learning How to Learn. Cambridge, England: Cambridge University Press.

Robertson, M. (1984). "Use of Videotape-Stimulated Recall Interviews to Study the Thoughts and Feelings in an Introductory Biology Laboratory Course." Ithaca, N.Y.: Unpublished M.S. thesis, Department of Education, Cornell University.

Robertson-Taylor, M. (1985). Changing the Meaning of Experience: Empowering Learners through the Use of Concept Maps, Vee Diagrams, and Principles of Educating in a Biology Lab Course. Ithaca, N.Y.: Unpublished Ph.D. dissertation, Department of Education, Cornell University.

Schwab, J. (1973). "The Practical 3: Translation into Curriculum." School Review, 81(4), 501-522.

Toulmin, S. (1972). Human Understanding. Princeton, N.J.: Princeton University Press.

ADDITIONAL RESOURCES
AAHE ASSESSMENT FORUM

The following resources are available for purchase from the AAHE Assessment Forum:

1. Resource Packet I: Five Papers **$15.00**

--"Assessment, Accountability, and Improvement: Managing the Contradiction," P. Ewell
--"Assessment and Outcomes Measurement: A View from the States," C. Boyer, P. Ewell, J. Finney, and J. Mingle
--"The External Examiner Approach to Assessment," B. Fong
--"Six Stories: Implementing Successful Assessment," P. Hutchings
--"Thinking About Assessment: Perspectives for Presidents and Chief Academic Officers," E. El-Khawas and J. Rossmann

2. Resource Packet II: Six Papers **$25.00**

--"Acting Out State-Mandated Assessment: Evidence from Five States," C. Boyer and P. Ewell
--"Assessing Student Learning in Light of How Students Learn," J. Novak and D. Ridley
--"Faculty Voices on Assessment: Expanding the Conversation," P. Hutchings and E. Reuben
--"Feedback in the Classroom: Making Assessment Matter," K. Patricia Cross
--"Standardized Tests and the Purposes of Assessment," J. Heffernan
--"An Update on Assessment," (AAHE Bulletin, December, 1987), P. Hutchings and T. Marchese

3. Three Presentations–1987: **$8.00**

from the 2nd National Conference on Assessment in Higher Education
--Lee S. Shulman -- "Assessing Content and Process: Challenges for the New Assessments"
--Virginia B. Smith -- "In the Eye of the Beholder: Perspectives on Quality"
--Donald M. Stewart -- "The Ethics of Assessment"

4. Three Presentations–1988: **$10.00**

from the 3rd National Conference on Assessment in Higher Education
--Alexander Astin -- "Assessment and Human Values: Confessions of a Reformed Number Cruncher"
--Linda Darling-Hammond -- "Assessment and Incentives: The Medium is the Message"
--Robert H. McCabe -- "The Assessment Movement: What Next? Who Cares?"

5. Assessment Programs and Projects: A Directory **$10.00**

Concise descriptions of thirty assessment projects being implemented on campuses across the country. Edited by Jacqueline Paskow.

To order items indicated above, contact: Patricia Hutchings, Director, AAHE Assessment Forum, One Dupont Circle, Suite 600, Washington, DC 20036; 202/293-6440. Orders under $25 must be prepaid. Allow four weeks for delivery. MAKE CHECKS PAYABLE TO AAHE ASSESSMENT FORUM.